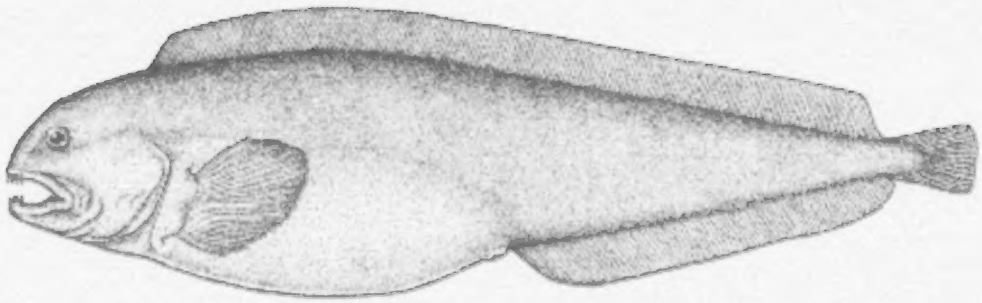
COSEWIC
Assessment and Status Report

on the

Northern Wolffish
Anarhichas denticulatus

in Canada



THREATENED
2001

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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Northern wolffish — from Scott and Scott, 1988.

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COSEWIC
Assessment Summary

Assessment Summary – May 2001

Common name
Northern wolffish

Scientific name
Anarhichas denticulatus

Status
Threatened

Reason for designation
Numbers of this large, slow-growing, long-lived, solitary, nest-building fish have declined over 95% in three generations, and the number of locations where the fish is found has decreased. Threats include mortality as by-catch and habitat alteration by bottom trawling. Dispersal is limited.

Occurrence
Arctic Ocean, Atlantic Ocean

Status history
Designed Threatened in May 2001. Assessment based on a new status report.

COSEWIC
Executive Summary

Northern Wolffish
Anarhichas denticulatus

Description

Wolffish are characterised by the prominent, canine-like teeth in the front of the jaws, the elongate body, and the lack of pelvic fins. The northern wolffish, *Anarhichas denticulatus*, is a large, benthopelagic predatory fish and is distinguished from the other two Atlantic species by the generally more uniform body colour, the soft jelly-like musculature, and the arrangement of the teeth on the roof of the mouth.

Distribution

The northern wolffish is found in cold, continental shelf waters across the North Atlantic from Norway to southern Newfoundland. In the western North Atlantic, it occurs in any numbers only off northeast Newfoundland. Elsewhere in Canadian waters, the species occurs only as an occasional stray.

Habitat

The northern wolffish is a benthopelagic fish found in a broad range of depths, but most often at depths greater than 100 m in offshore waters over soft bottoms and in proximity to boulders at temperatures below 5°C; it is usually found in deep waters between 151 and 900 m.

General Biology

Spawning occurs late in the year, and the demersal eggs are extremely large. Average fecundity is about 27,000 eggs/female. Maturity is reached at 5 years of age or more and the fish lives to at least 14 years; growth rates are slow but the fish can reach 145 cm in length and almost 20 kg in weight. It feeds mainly on bathypelagic and benthic invertebrates. Northern wolffish are non-schooling, non-migratory, and somewhat territorial.

Population Size and Trends

Scientific surveys from all parts of the western Atlantic range indicate declines in the abundance of northern wolffish over the past 20 years. Since 1978, abundance in the primary range off northeast Newfoundland is down by 98%. Numbers have declined steadily, the number of locations where the species occurs has declined, and the range may be shrinking.

Limiting Factors and Threats

Northern wolffish do not figure in commercial landings, although they are taken as by-catch. Canada and Greenland have been the major countries involved in the Northwest Atlantic fishery for the related Atlantic wolffish since 1980, and Portugal has been important in the 90s. Wolffish landings in the western Atlantic peaked in 1979 at around 22,000 tonnes but have fallen steadily to around 2,000 tonnes by 1997. Removals as by-catch have a negative impact on northern wolffish populations, and bottom trawling that destroys and disrupts spawning habitat is probably detrimental as well.

Existing Protection

Because the northern wolffish is not the target of a directed fishery in the North Atlantic it is unmanaged and there are no specific mechanisms, such as total allowable catch limits, in place that afford it protection.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.
** Formerly described as "Not In Any Category", or "No Designation Required."
*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

COSEWIC Status Report

on the

Northern Wolffish
Anarhichas denticulatus

in Canada

Niall R. O'Dea
Richard L. Haedrich

2001

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ABSTRACT

The northern wolffish, *Anarhichas denticulatus*, 1844, is a large blenny-like marine fish found in moderately deep and cold waters of the North Atlantic over rocky and hard bottoms from southern Newfoundland to Scotland. Never the target of a directed fishery, it is taken as by-catch. In Canadian waters, it has been abundant only off Newfoundland and Labrador, where it is a characteristic member of the deep cold-water fish assemblage on the shelf, but its numbers there, as indicated by scientific surveys, declined by 98% between 1978 and 1994, and the general picture of decline continues to the present. The species occurs only as a stray in other Canadian areas. Northern wolffish are relatively sedentary, local in their range and slow-growing. They make nests, and generally guard their large eggs. Wolffish feed mostly on midwater and bottom-living invertebrates. Aggressive trawl fisheries, now in abeyance by the imposition of widespread moritoriums, have had an impact on wolffish numbers. In Canada, numbers have declined steadily in scientific surveys, the number of survey locations where the species occurs is fewer, and the range appears to be shrinking. Slow growth, nesting habit and limited dispersal make rescue unlikely, and bottom trawling and dredging have probably damaged habitat.

SPECIES INFORMATION

Name, Classification

The wolffishes, family Anarhichadidae, are large, blenny-like marine fishes which inhabit moderately deep waters of the North Atlantic and North Pacific oceans. They are named for the large, conical, canine-like teeth employed in consuming the benthic crustaceans and invertebrates which are their chief food source. All four species of *Anarhichas* occur in Canada. The Bering wolffish, *Anarhichas orientalis*, lives in the Arctic Ocean; a little-known non-commercial species, it was identified as "Vulnerable" by COSEWIC a decade ago (Houston and McAllister, 1990). The other three species are found in the Atlantic and of these two, the spotted wolffish (*A. minor*) and the Atlantic wolffish (*A. lupus*), are of some commercial importance. The fourth remaining species, the northern wolffish *Anarhichas denticulatus*, is the subject of this report.

Description

The northern wolffish, *Anarhichas denticulatus*, is a thick, heavy-set fish with a heavy head, pointed snout and small eyes (Fig. 1). In common with all wolffish, it has distinctive and prominent large canine-like teeth in the front of the jaws and flattened, grinding teeth behind. There are no pelvic fins. Its body colour is grayish to dark chocolate with a light violet sheen and often has numerous but indistinct dark bars or spots. Living offshore over soft bottoms and in proximity to boulders at temperatures below 5°C, it is usually found in deep waters between 151 and 900 m. This species is

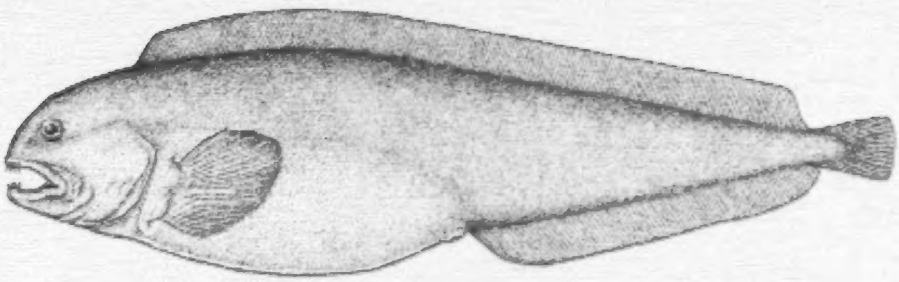

Figure 1. The northern wolffish *Anarhichas denticulatus*. From Scott and Scott, 1988.

the deepest living and also the most pelagic of all the Atlantic wolffishes. It feeds mainly on bathypelagic and benthic invertebrates and is known to reach 145 cm in length and almost 20 kg in weight (Barsukov *in* Whitehead *et al*, 1986; Scott and Scott, 1988).

DISTRIBUTION

Global Range

The northern wolffish inhabits the cold waters of arctic seas on both sides of the North Atlantic. Its southern range is limited. In Arctic waters, it has been found in Mould Bay, Prince Patrick Island, NWT (Hunter, 1984), and in the western North Atlantic at Greenland, off eastern Newfoundland, on the Flemish Cap, in the Gulf of St. Lawrence and Laurentian Channel, and, much more rarely, to the south around the Grand Bank and Sable Island Bank. There is a report of a single specimen caught off Canso, Nova Scotia (Merriman, 1935). In the eastern North Atlantic it is found from Iceland, the Faeroes, Finnmarken, the Murman coast and Novaya Zemlya (Whitehead *et al.*, 1986; Scott and Scott, 1988). The northern wolffish is basically a coldwater species, and Mahon *et al.* (1998) identify it as a characteristic member of the "northern, cold, deep, aggregated" demersal fish assemblage that occurs on the continental shelves off northeastern Newfoundland and Labrador. All three Atlantic wolffish species belong to this same assemblage.

The northern wolffish appears in the important regional ichthyofaunal compendia of the North Atlantic: "The Fishes of the British Isles and North West Europe" by Wheeler, 1969, pp. 450 (key and map only); "Fishes of the North-eastern Atlantic and the Mediterranean" by Whitehead *et al.*, 1986 as Clofnam species 165.1.2 on p. 1114; and "Atlantic Fishes of Canada" by Scott and Scott, 1988, pp. 430-431. The latter two accounts include keys, an illustration, distribution map and information on biology and relation to man as well as references. The species is not mentioned by Bigelow and Schroeder (1953) as ever being present in the Gulf of Maine.

Canadian Range

The ECNASAP (East Coast of North America Strategic Assessment Project) on-line Groundfish Atlas (http://www-orca.nos.noaa.gov/projects/ecnasap/ecnasap.html) summarizes twenty years of distributional data from scientific research surveys conducted in the western North Atlantic in the map NORWOL, reproduced here as Figure 2. ECNASAP is a joint US/Canada data synthesis and mapping project concerned with living marine resources and their habitats. The map shows that the distribution of northern wolffish in the western Atlantic is completely Canadian. In Canada, the northern wolffish occurs primarily off northeast Newfoundland and Labrador, and scientific survey data show the species to be at least 11 times more abundant there than it is in the region of next greatest abundance, the northern Gulf of St. Lawrence. In the southern Gulf of St. Lawrence and the waters south of Nova Scotia, the species occurs only as an occasional straggler. It is not recorded from the Gulf of Maine.

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HABITAT

Definition

The northern wolffish is a benthopelagic fish found in a broad range of depths from the surface to 900 m, but most often at depths greater than 100 m in offshore waters below 5°C. Unlike other wolffish, the northern wolffish can be found pelagically both as a juvenile and as an adult (Shevelev and Kuz'michev, 1990). Like other wolffish, it does not form large schools, and tagging studies (Templeman, 1984) suggest that it migrates but little. This limited migration makes the northern wolffish vulnerable to the impact of intensive local fishing and habitat destruction. The species has been observed defending a territory around a bait on the bottom from cod and haddock, and acoustic tracking over time showed that the size of that territory was quite restricted (Godo *et al.*, 1997).

Trends

Survey maps show that the number of sites where northern wolffish are caught steadily declines (Fig. 3). Stations where northern wolffish occurred are shown as closed dark circles and stations where they were absent by open circles. By the mid-90s, wolffish are encountered in far fewer places than they had been a decade earlier, and mainly at the offshore and deeper periphery of the range. This change has been a steady and unidirectional one since the mid-80s. In the early part of the series, almost 80% of sites at

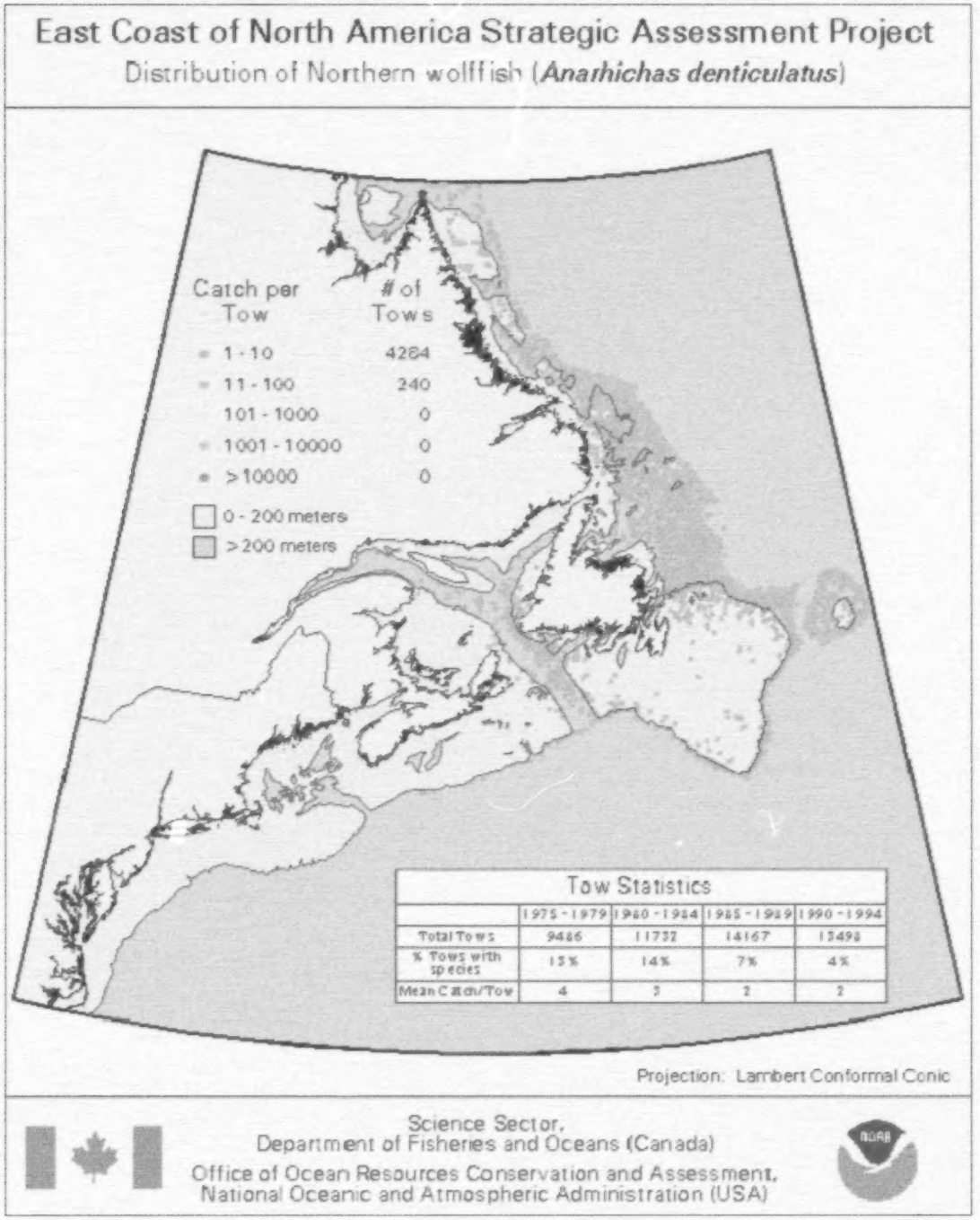
East Coast of North America Strategic Assessment Project
Distribution of Northern wolffish (Anarhichas denticulatus)
Catch per Tow
# of Tows
1 - 10 4284
11 - 100 240
101 - 1000 0
1001 - 10000 0
>10000 0
0 - 200 meters
>200 meters
Tow Statistics
1975 - 1979 1980 - 1984 1985 - 1989 1990 - 1994
Total Tows 9486 11732 14167 13498
% Tows with species 13% 14% 7% 4%
Mean Catch/Tow 4 3 2 2
Projection: Lambert Conformal Conic
Science Sector,
Department of Fisheries and Oceans (Canada)
Office of Ocean Resources Conservation and Assessment,
National Oceanic and Atmospheric Administration (USA)

Figure 2. Composite map of the western Atlantic distribution of *Anarhichas denticulatus*, from the ECNASAP website - http://www-ocra.nos.noaa.gov/projects/ecnasap/mpas/norwol.gif.

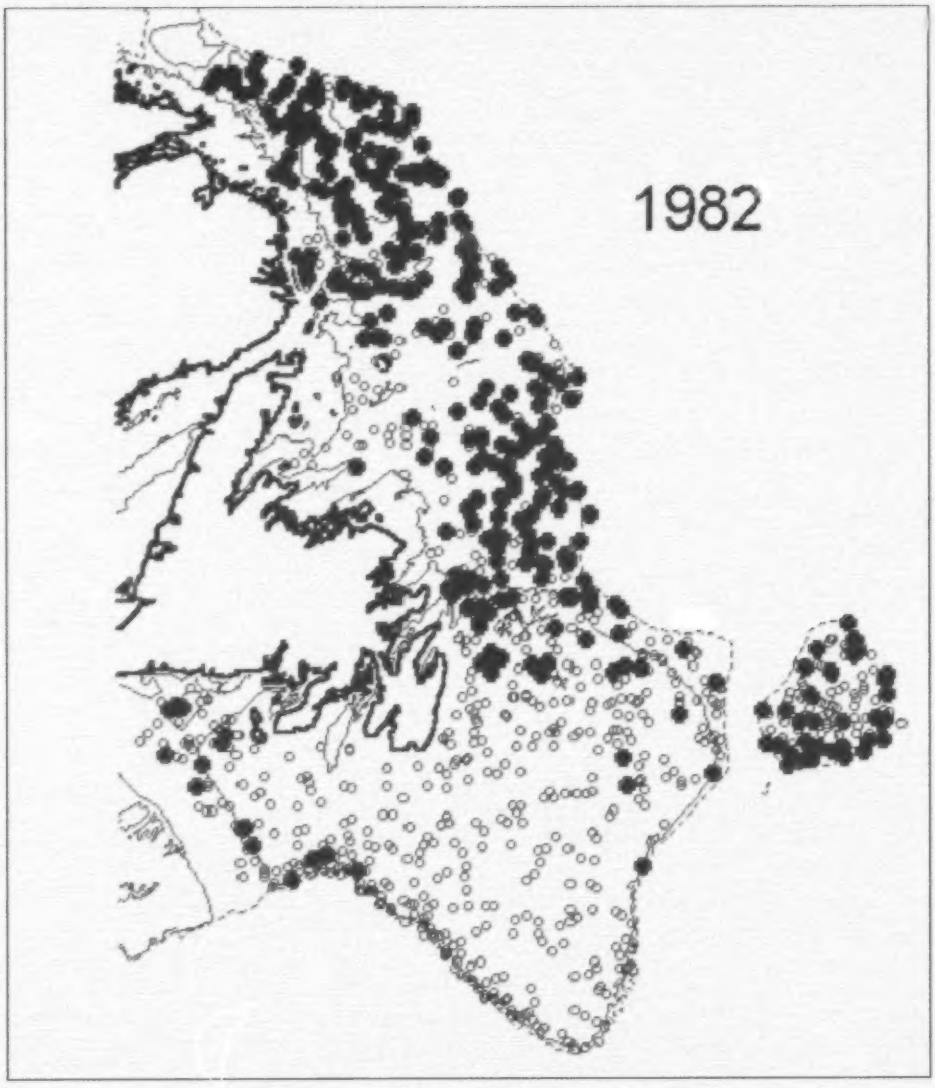

Figure 3a. Occurrence (presence/absence) of north wolffish, *Anarhichas denticulatus*, in Newfoundland waters in 1982. ECNASAP Data. Stations where wolffish occurred are indicated by a closed black circle, and stations where wolffish were absent by an open circle. The Flemish Cap, the isolated bank to the east, lies in international waters.

appropriate depths and temperatures for northern wolffish contained the fish, but by 1993 the percentage had dropped to a mere 3.6% (Fig. 4). The 1986-1999 DFO data show a similar trend as indicated by the generally declining percentage of successful wolffish tows over time, although the number is up somewhat in the two most recent years.

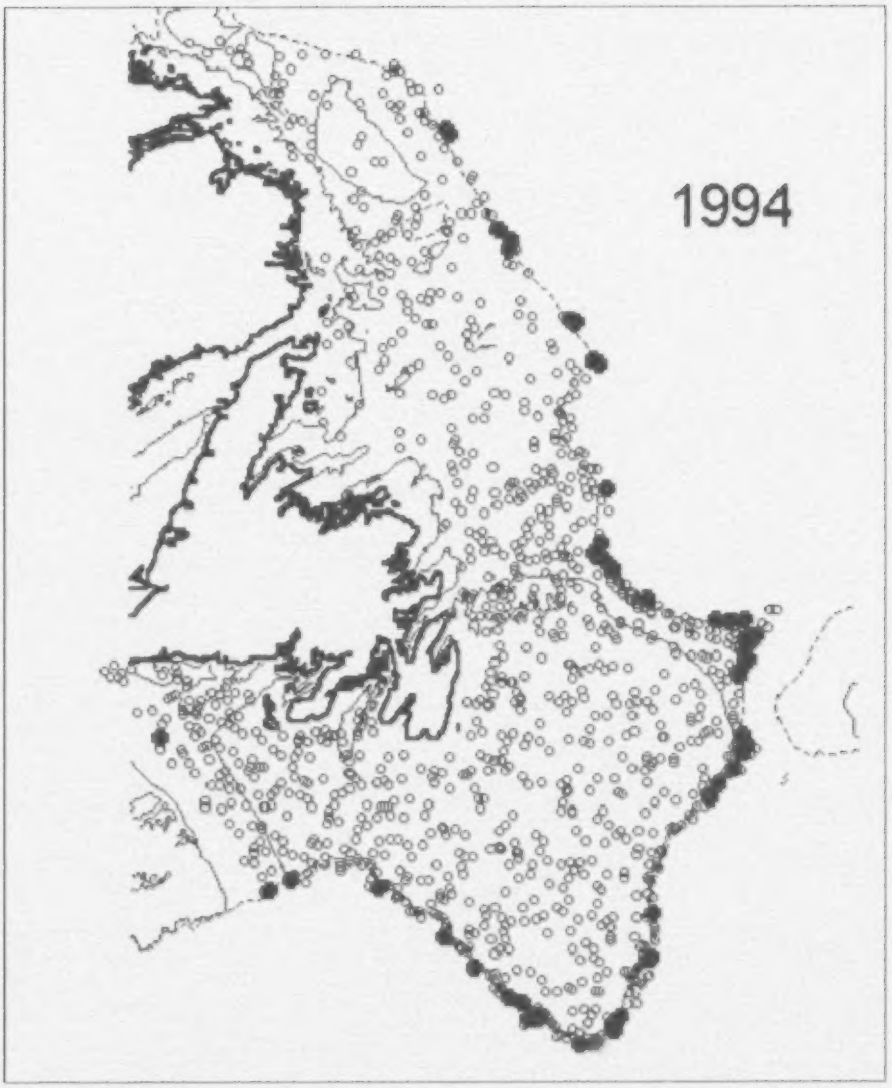

Figure 3b. Occurrence (presence/absence) of northern wolffish, *Anarhichas denticulatus*, in Newfoundland waters in 1994. ECNASAP Data. Stations where wolffish occurred are indicated by a closed black circle, and stations where wolffish were absent by an open circle. Note that there are more deeper samples than there were in 1982. No data from Flemish Cap were available.

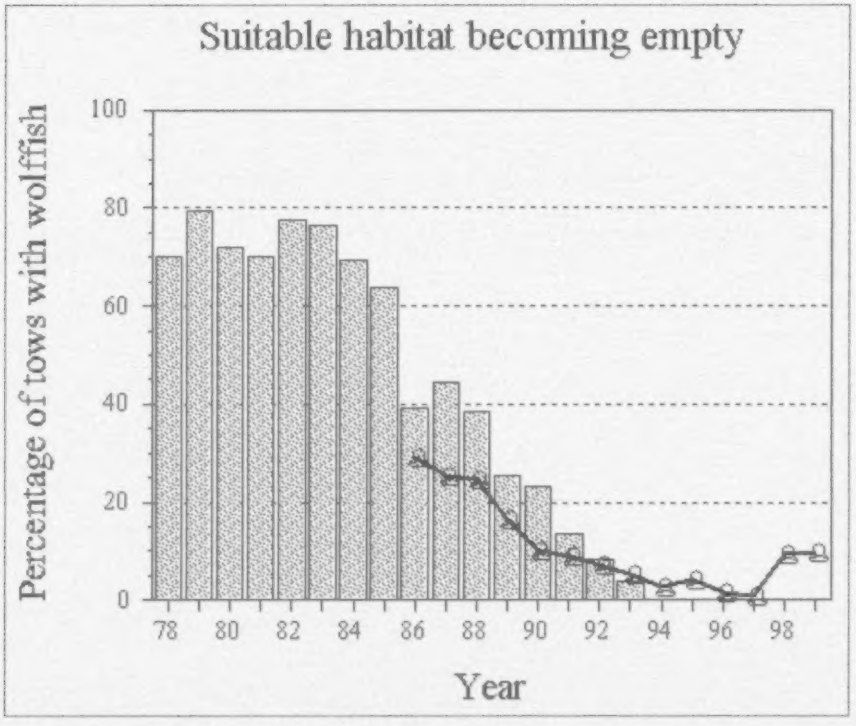

Figure 4. Bars: Percentage of stations within appropriate depth and temperature ranges where the northern wolffish, *Anarhichas denticulatus*, was caught, 1978-1993 off Newfoundland. The ranges are those within which the wolffish is most likely to be encountered (Fischer and Haedrich, 1999), 100 to 900 m for depth and -0.6 to 5.0°C for temperature. Line: percentage of survey tows which took wolffish 1986-1998; information provided by DFO in July 2000.

GENERAL BIOLOGY

Reproduction

Research in the Barents Sea suggests that the northern wolffish spawns over a long period from April to October. In the western North Atlantic, they are thought to spawn in autumn and early winter. The northern wolffish spawns in deep water on the continental slope, subsequently returning to the shelf (Shevelev and Kuz'michev, 1990). Large females (over 100 cm) contain on average around 27,000 eggs, more than any other wolffish species (Gusev and Shevelev, 1997), and these can range up to 8 mm in diameter. Neither egg clusters nor hatching have been observed, but the larvae are known to be pelagic.

Growth rates of the northern wolffish in Canadian Atlantic waters are unknown. In the Barents Sea they appear to grow quickly during their first four years. Living to upwards of 14 years, Canadian specimens may grow to 145 cm in length and 19.5 kg in

weight. The minimum size of northern wolffish at maturity is 80 cm in length, at which size otolith data indicate the fish would be about 5 years old.

Nutrition and Interspecific Interactions

The northern wolffish feeds on bathypelagic and benthic invertebrates, such as comb jellies, jellyfish, crabs, brittle stars, and starfish. The crustaceans and molluscs on which it feeds tend to be softer shelled than those eaten by other wolffish species, and tend to be fixed less firmly to the bottom substrate since the northern wolffish's relatively weaker teeth are poorly-suited for atacking heavily-armoured prey; sea urchins, nonetheless, have been reported among its stomach contents. The diet of the pelagic young are planktonic invertebrates and fish eggs and larvae, exactly the same as in other wolffish species (Baranenkova *et al.*, 1960). Though not known to be an important prey species, the northern wolffish has been reported in the stomach contents of ringed seals, golden redfish, cod, and Greenland shark. Contamination studies of deepwater fish in the Davis Strait found relatively low levels of organochlorines in northern wolffish livers (Berg *et al.*, 1997).

POPULATION SIZE AND TRENDS

Data from random-stratified scientific survey trawls northeast of Newfoundland, the primary range of the northern wolffish, are available from 1978 to 1996 (Atkinson, 1994), and cover an area of 265,365 km^2 (the statistical area to the south, 3L, was not surveyed until 1981). The surveys are intended mainly to assess the size of commercial fish stocks, but they also catch most species in the demersal fish community (Brown *et al.*, 1996). Each trawl sample traverses a bit over 2 km across the seabed, and the number of individual research trawl tows made (the number of stations) in any one year can be as many as several hundred.

The number/tow (what fisheries biologists call the "catch per unit effort" or CPUE) is used as an index of population size. Over the period from 1978 to 1996, this index was calculated both as the total number of northern wolffish caught in a year divided by the number of stations sampled at appropriate depth and temperature ranges for the species in that year, and more simply as the total number of wolffish caught in a year divided by the total number of stations. The appropriate depth and temperature ranges are determined using the niche axis approach developed by Fischer and Haedrich (1999) and represent the ranges of those two environmental parameters within which the fish is most likely to be encountered. For northern wolffish the ranges are 100 to 900 m for depth and -0.6 to 5.0°C for temperature.

The scientific survey data, no matter how presented (Fig. 5a-c), indicate a precipitous decline in the population size of the northern wolffish in its core range. From 1978 to 1980, between 2.7 and 3.1 individuals were caught in each tow at appropriate depths and temperatures (Fig. 5a). By 1986 the number/tow had dropped to less than 1. In the ten years from 1984 to 1993 the number/tow declined steeply and continuously, from 2.3 in 1984 to a mere 0.03 in 1993. The population decline rate over the full ECNASAP time series, 16 years or about three wolffish generations, is 98%. In the northern Gulf of St. Lawrence, where the wolffish is much less abundant (average no/tow over all years = 0.02), the overall population decline has also been very great, 97% from 1983 to 1994. Since 1995, a different sampling protocol has been followed off Newfoundland (bigger net, smaller mesh, faster speed, shorter time), and results cannot be strictly compared. Nonetheless, numbers do remain very low and there has been no significant change in the downward trend. From 1986 to 1999 (two wolffish generations and the period for which DFO provided recent data) the adjusted decline rate is 97% (Fig. 5a).

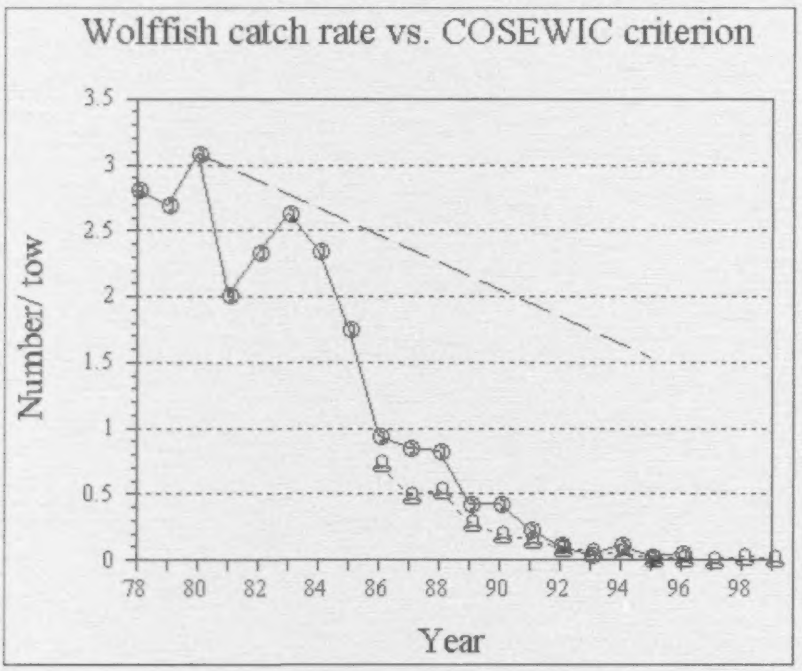

Figure 5a. Catch rates for northern wolffish, *Anarhichas denticulatus*, caught in fall survey tows within appropriate depth and temperature ranges off Newfoundland, 1978-1996. The ranges are those within which the fish is most likely to be encountered (Fischer and Haedrich, 1999), 100 to 900 m for depth and -0.6 to 5.0°C for temperature. Catch rates for 1986-1998 (dotted line) are from information provided in July 2000 by DDFO. Data for 1995-1998 were collected using different sampling protocols which are expected over-estimate parameters relative to earlier samples; these rates are adjusted by the Campelen/Engels conversion factor 3.1 (Bundy *et al.*, 2000). The dashed line shows COSEWIC "Endangered" criterion, 50% decline over three generations.

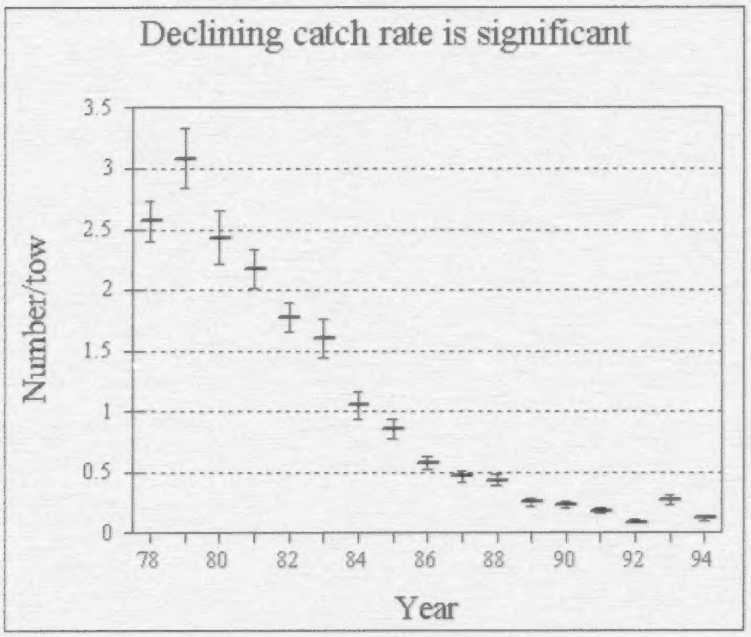

Figure 5b. Mean catch rate (number/tow) and standard error of the mean for northern wolffish, *Anarhichas denticulatus*, caught in all tows in Newfoundland waters, 1978-1994. ECNASAP data.

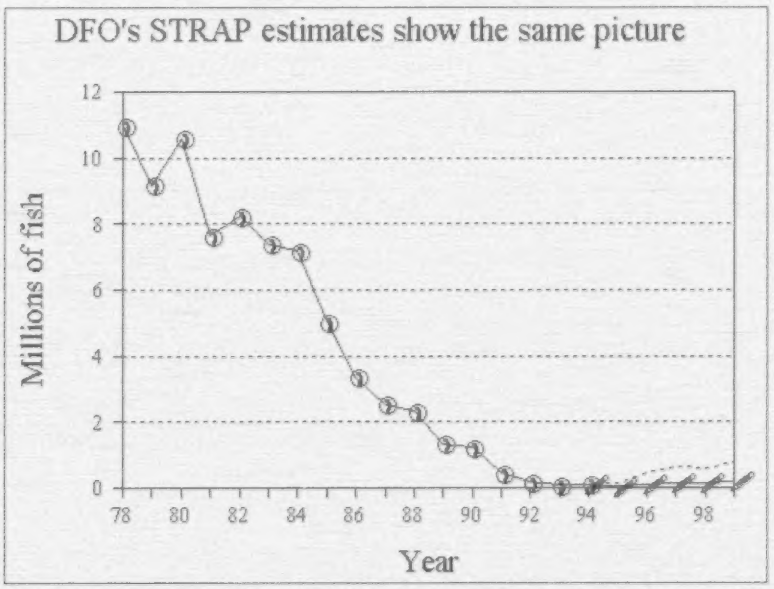

Figure 5c. Twenty years of STRAP analyses for northern wolffish, areas 2J3K (the only ones where a full time series is available). Solid line, filled circles: Engels trawl estimates. From 1978 to 1994 (16 years, i.e. 3 generations) there was no change in sampling method, and the decline is 99%. Dotted line: uncorrected estimates from later samples using Campelen trawls, 1995 to 1999. Solid line, small dots: corrected estimates using the factor 4.11 (see footnote p. 13), 1995-1999. Based on information provided by DFO in September 2000.

DFO's main population assessment tool is the STRAP computer program. This analysis takes survey trawl catches within defined strata, scales them according to the total area of the stratum (within which the species is assumed to be uniformly abundant), and calculates an estimated number of fish presumed present. To get a total, those numbers are summed across all strata where the fish was encountered. The size of a single stratum can range from 30 to 2817 square nautical miles. With an average stratum size of 697 sq n mi (25,748,576,526 sq ft) and with each survey trawl covering approximately 274,000 sq ft, the scale-up is prodigious (Schneider *et al.*, 1999).

STRAP analysis results for northern wolffish from 1986 to 1999 are shown in Table 1 (see also Fig. 5c). Because the sampling protocol changed in 1995, values after 1994 must be divided by a correction factor for comparability. For wolffish, that factor ranges from 3.1 for adults to 10.7 for juveniles (Bundy *et al.*, 2000). The STRAP results also indicate a large decline in the wolffish population, down 95% over the 9 years from 1986 to 1994 (no change in sampling). From 1986 to 1999, a little over 2 wolffish generations and with the later catches adjusted by 3.1[1], the decline indicated is 91%. Despite the questionable value of STRAP's absolute numbers, it was comforting to find that the annual estimates are very well-correlated ($r = 0.99$) with the metric we prefer and use above, the number/tow.

The number of fish taken in each successful wolffish trawl has declined significantly over time. In 1978, 7% of the collections contained more than 30 specimens, and about half (52%) contained less than 5. By 1984, only 2% of the collections had more than 30 fish. In 1993, there were no large individual collections at all; 100% of the stations which encountered northern wolffish took no more than two specimens, and most commonly (81% of stations with wolffish) there was only 1. Since 1995, because the sampling gear changed, this analysis cannot be continued.

Size data (Fig. 6) indicate an increase in average size for the northern wolffish over the first half of the time period; given its extremely low abundance, this indicates that the great majority of remaining fish were older and larger and that there had not been any significant recruitment. In the more recent data, the size has begun to diminish steeply. Because the data show that numbers are also declining at the same time, this decrease in size is not the result of increased recruitment. It means that the large adults are beginning to vanish. Sizes are up in 1998 and 1999, but this is probably related to the sampling regime. The fish that comprise these samples come mostly from tows deeper than 700 m. That bigger fish are found in deeper depths is a commonplace (Heincke's rule) among marine fish.

[1] The number is conservative; calculation following Bundy *et al.* (2000) indicates the factor for northern wolffish alone should be 4.11.

Table 1. DFO's estimated numbers of northern wolffish in Newfoundland waters. This information, the result of the Department's standardly applied STRAP analysis, was provided by DFO in July 2000. Estimates in and after 1995, when the sampling protocol changes, are adjusted by the Campelen:Engels factor 3.1 (Bundy *et al.*, 2000)

	Estimated number of northern wolffish - Divisions 2J3KL		Number actually caught in survey
Year	Maximum	Minimum	
1986	5,808,387.23	2,718,305.33	259
1987	3,841,278.98	1,971,849.23	224
1988	4,697,189.12	1,974,060.30	225
1989	2,654,789.50	976,701.07	125
1990	2,452,320.62	694,660.54	108
1991	1,093,983.10	269,964.44	107
1992	1,285,607.56	-622,541.34	58
1993	307,233.38	-18,136.13	41
1994	396,742.14	15,467.53	34
1995	172,054.16	-28,049.17	33
1996	624,824.28	18,523.19	14
1997	542,174.41	90,460.37	7
1998	509,457.58	128,370.08	21
1999	624,961.46	184,273.49	15

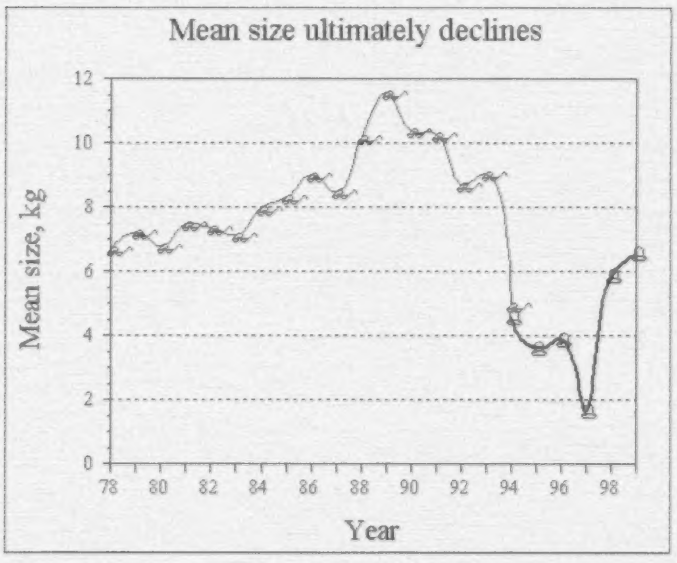

Figure 6. Mean size of northern wolffish, *Anarhichas denticulatus*, 1978-1999. DFO Newfoundland Fall Survey Data. Uncorrected data from 1995-1999 (x's, heavy line), provided by DFO in July 2000, were collected using different sampling protocols which are expected to over-estimate parameters relative to earlier samples.

LIMITING FACTORS AND THREATS

There are no direct studies of factors responsible for the declines observed in wolffish abundance. Following the dramatic collapse of the northern cod off Newfoundland in 1992, however, a number of causes for that decline were suggested, including especially environmental changes. But the emerging consensus today is that, while environment may have played some role, overfishing was clearly the primary cause of the declines observed in cod and other groundfish species (Sinclair and Murawski, 1997; Villagarcía *et al.*, 1999). When assessed over only a slightly longer time scale, fishing in the area is argued to have been responsible for the extraordinary decline of the non-commercial but large and once abundant and widely-distributed barndoor skate, *Raja laevis* (Casey and Myers, 1998).

The northern wolffish is not the target of a directed fishery, but is taken as by-catch by offshore trawlers. When caught, it is discarded.

In fisheries data compiled by the Food and Agriculture Organization of the United Nations (FAO), wolffish landings for the western North Atlantic are reported for the whole family rather than for each individual species. Though the northern wolffish is discarded when caught and therefore not recorded in landing data, it can be assumed that its catch amounts closely parallel those of its exploited relatives. Wolffish landings in the northwest Atlantic hovered around 5,000 tonnes through the 1950s and then rose through the 1960s and 1970s to a peak of 22,000 tonnes in 1979. Landings then declined steadily through the 1980s and 1990s; in 1984 they stood at 6,000 tonnes and by 1996 they had fallen to 1,700 tonnes but were up to almost 2000 tonnes in 1997.

Apart from the direct adverse impact fisheries have on northern wolffish, human activities also have indirect and detrimental effects. The groundfish trawls in which wolffish are caught result in incidental mortality and damage to fish which come in contact with the gear but are not caught. Perhaps even more importantly, the steel doors of the net, along with heavy bottom lines and rollers, scour the seabed (Watling and Norse, 1998). This can cause significant habitat damage by removing or re-distributing the rocks and boulders under and around which these fish shelter, spawn and build nests. Studies on Georges Bank (Collie *et al.*, 1997) and in the Gulf of Maine (Auster *et al.*1996), areas similar to but south of the northern wolffish's range, show the considerable degree of damage that can result from bottom dragging. Jennings and Kaiser (1998) provide an excellent overview of the impacts fishing has on habitat. Impacts can vary quite a bit depending on local conditions, but the greatest and most lasting impacts occur on hard substrates in deep water, just those habitats where the wolffish are found.

Bottom trawling for fish and dredging for scallops and clams, in addition to digging up and disrupting bottom habitats, also resuspend bottom sediments which can smother spawning areas and damage gills. Other activities such as dredging and aggregate extraction harm bottom habitats on the Canadian continental shelf by destabilizing the seabed, increasing erosion, and polluting previously healthy areas (Messieh *et al.*, 1991).

The period since 1992 is an anomalous one for all these waters. Relative to the past, fish populations are at an all-time low. For that reason, bans on fishing have been in effect in most regions for various periods of time, and these continue in the Newfoundland region. Fishing predation is thus much relaxed, and populations should do better as long as that situation continues, which will not be forever. A cornerstone in the Fisheries Resource Conservation Council's approach to management (this quasi-independent group advises the Minister on the status of commercial fish stocks) is adherence to the precautionary principle (FRCC, 1996). That principle - when in doubt, err on the side of the fish - should also apply in regard to COSEWIC status.

SPECIAL SIGNIFICANCE OF THE SPECIES

While occasionally eaten by Greenlanders, the northern wolffish's jelly-like flesh is not generally favoured by people and neither is its skin suitable, like that of the spotted wolffish, for tanning into leather. Though its role as a forage fish is undetermined, it does appear to be a food source for several species. Because of its generally low abundance, however, it is most unlikely to be an important prey species.

EVALUATION AND PROPOSED STATUS

Existing Legal Protection or Other Status

Because the northern wolffish is not the target of a directed fishery in the North Atlantic it is unmanaged and there are no specific mechanisms, such as catch limits, in place to afford this species protection. Possibility for protection may exist under the Habitat Section of Canada's Fisheries Act. The Canadian Atlantic groundfish moratorium imposed in 1992 in response to the collapse of the fishery for Atlantic cod provided indirect protection for the wolffish by reducing trawling pressure. The northern wolffish currently has no status under COSEWIC, IUCN, or other conventions on species protection.

Assessment of Status and Authors' Recommendation

Under IUCN Categories and Criteria criterion A: 'Declining Population', the northern wolffish, with its 98% decline rate, would fall in the category Critically Endangered, defined as a "population decline rate at least 80% in 10 years or 3 generations."

Musick (1999) feels that marine fish, by virtue of their widespread distribution and thus relatively great abundance, should be treated differently from other species in respect to consideration as species at risk. He proposes an approach that involves two steps, first determining the productivity class of a species (based on growth, fecundity and age characteristics) and then classifying it on the basis of arbitrary decline thresholds. The northern wolffish, on the basis of age at maturity and lifespan, falls in Musick's (1999) 'Low' productivity category, and, exhibiting a decline of 98% over three generations, is well above Musick's suggested 85% decline threshold cutoff for species in the Low category.

According to Musick's proposed scheme, the northern wolffish would automatically be listed as Vulnerable and would then be subjected to closer scrutiny for final classification. That scrutiny would explicitly consider issues concerning the shrinking range, local distribution, nesting habit, and possibility of habitat destruction. The data available on all these issues support upgrading to Threatened or Endangered.

Hutchings (2000, 2001) finds that exemption of marine fish from established species-at-risk criteria (as Musick suggests) cannot be supported on the basis of a large body of available scientific data and that do to so would be inconsistent with a precautionary approach to fisheries management and the conservation of biodiversity. He argues that extinction risk alone is not very useful from either a management or an ecological perspective and that the other face of the issue, the likelihood of recovery, should be weighed seriously in assigning status. He suggests a classification scheme that would replace Vulnerable to Critically Endangered with Conservation Categories ranging from Priority I to IV. The empirical data show that population recovery in marine fish is negatively correlated to the magnitude of population decline. With the very high decline rate of 98%, the likelihood that northern wolffish populations would show signs of recovery after 15 years is very low, and this species would fall in Hutching's Conservation Category Priority IV, his highest rating.

The scientific survey data indicate a 98% decline in the Canadian population of northern wolffish over 3 generations, the 15 years from from 1978 to 1993. Under criterion A: 'Declining Population' of COSEWIC's Risk Categories and Criteria, this population decline rate places the northern wolffish well within the category Endangered, defined as a "population decline rate at least 50% in 10 yrs or 3 generations." Consideration of all other information available on the biology of this species suggests no reason why this classification should be modified. On this basis we recommend that the northern wolffish, *Anarhichas denticulatus*, 1844, be designated an Endangered Species. This designation is consistent with evaluations based on other schemes as well, as outlined above.

Summing up:

a) The northern wolffish, *Anarhichas denticulatus*, 1844, is eligible for assessment because it breeds in Canada and has its centre of distribution there in the western Atlantic.

b) Numbers have declined steadily by 98% as shown in scientific surveys (Fig. 5), the range is shrinking (Fig. 3), and the number of locations where the species occurs has declined (Fig. 4).

c) Slow growth, nesting habit and limited dispersal make rescue problematical. Populations in Greenland are separated from Canada by a broad expanse of unsuitable deep water in the Labrador Basin.

d) Bottom trawling and dredging have probably damaged habitat.

TECHNICAL SUMMARY

Anarchichas denticulatus
Northern wolffish, loup à tête large

Suborder Perciformes, Family Anarhichadidae; large (150 cm, 20 kg), long-lived, benthopelagic, territorial, solitary, fish; diet comprised mostly of invertebrates; inhabits deep, cold waters and rocky bottoms.

Distribution	
• *extent of occurrence (sq km)*	>400,000 km^2
• *area of occupancy (sq km)*	Increasingly found at fringes of distribution
• *range jurisdictions (occurs in which provinces & territories?)*	NF,NS,QC, Nunavut
Population information	
• *total number of individuals in Canadian population*	Unknown
• *number of mature individuals (capable of reproduction) in the Canadian population*	Unknown
• *generation time (indicate years, months, days, etc.)*	5 years minimum
• *population trend (decline, stable, increase, unknown)*	Decline
• *if in decline, % decline over 10 years or 3 generations whichever is greater (or specify if for shorter time period)*	98% over 3 generations
• *number of sub-populations (geographically or otherwise distinct groups between which there is little exchange i.e. <= 1 successful migrant / yr)*	Unknown
• *number of individuals in each sub-population*	Unknown
• *number of extant sites*	Unknown
• *number of historic sites from which species has been extirpated*	In 1994, found in *ca.* 3% of sites where expected
• *is the population severely fragmented (most individuals found within small and relatively isolated sub-populations)?*	Yes
• *does the species undergo extreme fluctuations (population size or distribution area varies widely, rapidly, and frequently (typically >1 order of magnitude))?*	No
Threats (actual or imminent threats to populations or habitats)	
Anthropogenic influence: aggressive fishing with wolffish killed as bycatch Habitat loss: nesting and shelter habitat can be extensively damaged by bottom trawls	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	Yes
• *status of the outside population(s)?*	Unknown
• *is immigration possible?*	Yes
• *would immigrants be adapted to survive here?*	Probably
• *is there sufficient habitat for immigrants here?*	Unknown
Criteria met and category: satisfies COSEWIC A1b for "Endangered"	
Precautionary Principle applicable.	
Sources of Information: ECNASAP database; DFO scientific survey cruises 1978-1996, with additions to present. Literature cited in report.	

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